

Status Report #4

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## Status Report

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### General Information:

#### Personnel.

Presently working on the project full time are one instrument maker and one electronics technician. Another electronics technician is working 1/2 time. The development of a large volume solid state detector has been assigned to a graduate student as a Ph.D. thesis.

#### Progress Report:

The emphasis during the report period has been almost exclusively on the development of large volume Li drifted Ge detectors.

##### (a) Development of Large Volume Li-drifted Ge Detectors.

Early this period 6 detectors were fabricated which detected gamma rays. A spectrum showing a peak from  $\text{Na}^{22}$  511 Kev gamma rays is shown in Fig. 1. This exhibits our main problem at that time. We had not found a way to properly apply the "cleanup drift". Consequently, leakage current was large, and the 20 Megohm load resistor in our preamplifier precluded the setting of biases high enough to suitably decrease the detector capacitance. Consequently, the preamplifier noise dominated the resolution, and was responsible for nearly all of the line width exhibited in Fig. 1.

Subsequent work showed new problems, as the quality of the diodes decreased in the next 4 attempts. We finally found the solution to this as being a considerably more rigorous treatment of the diode edges. Since this treatment the diode quality has greatly improved, well beyond the best previous ones.

Much was learned about the many different, and independently important facets of diffused junction diodes and Lithium drifting in Germanium. Progress earlier in the report period was largely due to a refining of laboratory procedure and a more careful and educated choice of materials.

Early difficulties with drifting diodes that had good voltage characteristics were taken directly to our prime supplier of materials; Sylvania in Towanda, Pennsylvania. The problems that were discussed were common to several labs trying to drift lithium into germanium at that time. The engineers at Sylvania believed that the difficulties were largely due to an oxygenation of the crystals during the growing stages. They began preparing material immediately after this discussion that were very nearly free from this type of contaminant. The first batch of crystals that were received of the newer type of crystal, provided us with the first diffused diodes that increased apparent resistivity with time.

A visit by Dr. G. Dearnaley at the end of March offered us a chance to discuss our procedure with him. The outcome of the discussion was that a few very small changes or additions to our process would most likely have large effects. The most important points discussed were as follows:

Evaporation and Diffusion of Lithium: It was noted that the most recent methods that we use were those that had also given him the best and most reproducible results. That is;

1. Bring the substrate up to the temperature that is to be used during diffusion.
2. Evaporate Lithium and diffuse simultaneously for ten to twelve minutes.
3. Cool quickly by bleeding super-dry nitrogen to the bell jar.

The idea of heating the Germanium substrate by radiation heating was received favorably.

Reagent Purities: The distilled water that we use has a resistivity measured to be 0.20 megohm-cm. It was suggested that we improve the purity to 1 megohm-cm or better. This was found by Dr. Dearnaley to have been a cause of poor and variable results. Consequently we purchased a deionizer to purify the water just before it was used.

Drifting: The importance of a carefully controlled ambient environment was discussed. Dr. Dearnaley agreed that our idea of drifting in vacuum virtually eliminated the chance of sudden change of the ambient environment and provided the greatest freedom from water vapor.

In order to test our conclusions and the suggestions of Dr. Dearnaley new samples were prepared in which the edges were carefully sawed off and then ground and polished prior to the drifting. The results of this treatment were very gratifying. Figures 2,3, and 4 show spectra of  $\text{Na}^{22}$ ,  $\text{Bi}^{207}$ , and  $\text{Co}^{60}$  taken with one of the new detectors. The detector resolution determined from these measurements is  $\Delta E = 13 \text{ kev FWHM}$ . Taking into account the fact that this detector - owing to our impatience to test it - had been drifted to a depth of only 2 mm we expect that a more deeply drifted specimen will compare favorably with the best commercial detectors which have  $\Delta E = 6 \text{ keV}$ .

In the meantime an electrolytic polishing machine has been built and is presently undergoing tests. A spark cutter purchased by another group in this department will be available shortly and both instruments should help us to further improve the surface treatment of our detectors.

Keeping in mind that the manufacture of disc shaped detectors was only a preliminary to the development of cylindrical detectors we have prepared in the meantime all the apparatus necessary to handle these detectors and plan to proceed with their manufacture in the near future.

(b) Investigation of Solid State Properties and Effects that Might be of Importance to the Development of New Particle Detectors.

Techniques for the vacuum deposition of  $\text{Al-Al}_2\text{O}_3$  - Pb superconducting tunnel diodes had been developed to a

point where reproducible diodes can be manufactured routinely. The signals seen during earlier tests were not seen again and were presumably not related to the presence of  $\alpha$  particles. Because of our concentration of Li drifted detectors and because the low temperature facilities of the department are presently being expanded, further work on this effect has been postponed.

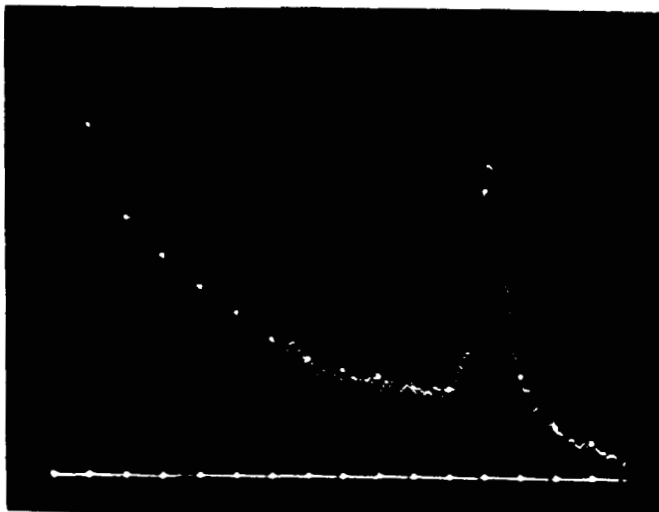


Fig. 1  
Na-22: 511 kev gamma line, zero  
suppressed 111 channels  
S#6A



Fig. 2  
Na-22: 511, 1260 kev gamma line,  
and pulser peak

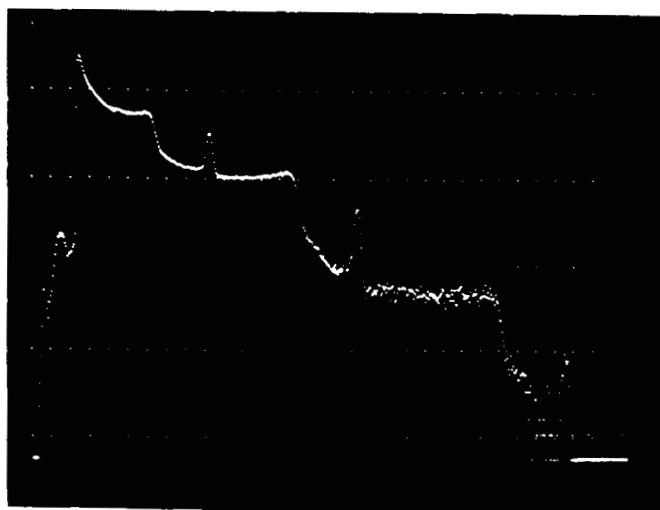


Fig. 3  
Bi-207: 570, 1060, 1770 kev gamma.  
(logarithmic display)

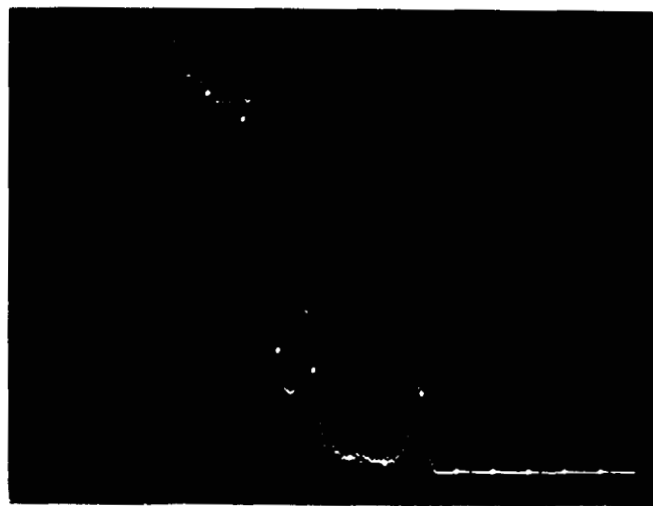


Fig. 4  
Co-60: 1330, 1170 kev gamma line.  
zero suppressed 250 channels